EET SENIOR DESIGN PROJECT REPORT

Bullet Proof Battery System

Submitted to

Professor (Elaine Cooney)
Engineering Technology Department
by
Walla Alshafie|Vincent Rutahintare| Tiffany Lanteigne

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EXECUTIVE SUMMARY

With the continued use of renewable energy where the battery is an important element(energy storage element), therefore, it is important to develop a device that will effectively maintain the battery charge to preserve its functionality over time.
In our senior design project, as requested by the customer Chuck Grimm, we are developing a microcontroller-based device which will protect the battery from overcharging and high temperature. Current lead-acid batteries in Haiti where they are being used only last a couple of weeks due to massive misuse because of a lack of understanding about electronics. Our goal is to make a battery that can last 52. The LEDs will be used to display the charging & discharging status of the battery and the BPB system will automatically protect the battery without the intervention of the user.

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REVISION HISTORY

Version	Date	Revised by	Description
1.0	18 Nov 2020	VR	Initial version
1.1	18 Nov 2020	VR	Added executive summary, intro, and specification requirements
1.2	19 Nov 2020	TDL	Revised specification requirements and added high-level design
1.3	20 Nov 2020	TDL	Added parts list
1.4	20 Nov 2020	TDL	Added testing procedures, references, and recommendations
1.5	23 Nov 2020	WM	Fixed the paragraphs based on the updates of the project
1.6	1 Dec 2020	TDL/WM/VR	Added system testing results and conclusion
1.7	10 Dec 2020	TDL WM	Added Project Timeline Review and add mechanical layout, BOM, wiring Diagram

1. Introduction

Current lead-acid batteries in Haiti only last a couple of weeks due to massive misuse because of a lack of understanding about electronics. Our goal is to make a battery that can last 52 weeks in Haiti which is why the project is called the Bullet Proof Battery Project. Our customer is Chuck Grimm, a software engineer with over 20 patents to his name, who wants to use the bulletproof battery we build to power electronics in Haiti via solar energy. Our battery is going to be used to power laptops, and projectors to teach students how to read and write because education is lacking in a lot of areas in Haiti.

Our battery project needs to have a microcontroller that monitors the battery so that the microcontroller can check for changes in the environment. It needs to check for: the temperature of the battery, water leakage inside. battery charge level and control of charge and discharge for safe use. It also needs to help the cooling-off of the battery and accelerate the drying of any terminals to prevent damage to the battery.

Scope

The scope of Haiti BBP is to:

- Increase the longevity of lead-acid batteries
- Monitor internal temp and break contacts if the system goes above-set limits
- Develop a sturdy enclosure for the BBP which guards against high temperature, water leakage,eBay and fall damage
- Integrate microcontroller monitoring of the enclosure environment and statistics
- Decrease the cost of the battery (less than $50 ideally)

System Overview

The BulletProof Battery Project is made with a smart circuit to monitor the charging and discharging rate of a lead-acid battery. The smart circuit will be monitored by a microcontroller that will produce real-time measurements on the associated variables, (I.E. temperature, voltage, charging status, etc..). By limiting the user's ability to interfere with the function of the battery, battery life will have been increased.

2. SPECIFICATION REQUIREMENTS

The BPB will ensure that the battery meets the following requirements:

Table 1 - Engineering Specifications

#	Source	Specification	Justification	Priority
1.01	Customer	52 Week Life Cycle	Battery life/Main goal of the project	High
1.02	IEEE Standards	Housing Temp 120 F Max	Durability/Prolongs battery life	High
1.03	NEMA Standards	**NEMA 4X Rating**	Durability	High
1.04	Customer	Charge Limit 100% or 13.7V	Durability/Prevents overcharging/Prolongs battery life/Prevents explosions/Prevents hydrogen sulfide from being produced	High
1.05	Customer	Discharge Limit 70% or 12.4V	Durability/Prevents over-discharging/Prolongs battery life/Prevents acid stratification and sulfation	High
1.06	Customer	5 ft/1.5 m drop	Durability	Medium
1.07	Customer	Dimensions: 17.6” L x 10.0” W x 10.7” H	Moved by no more than two people	Low
1.08	Customer	Weigh no more than 50 lbs	Moved by no more than two people	Medium
1.09	IEEE Standards	Charge battery in a ventilated room	Prevents the build-up of hydrogen gas/Prevents explosions	High
1.10	Matt Brown & Eric Philbrook	Space out the circuit board	Prevents shorts circuiting	High
1.11	IEEE Standards	Match charger to battery requirements	Prolongs battery life	High

NEMA 4X Rating only applies to portions that house electrical components

Documentation Requirements

Table 2 - Documentation Requirements

#	Source	Requirement	Priority
1	Technical Manual	Preventative Measure	**High**
2	Direct Support	Customer Service	**Low**
3	General User's Manual	Operation	**High**
4	French Creole Translation	General User's Manual translated to French Creole	**High**

3. HIGH-LEVEL DESIGN

BulletProof Battery: Part List				
Item Number	**Part Number**	**Description**	**Quantity**	**Vendor**
1	PIC16(L)F15313/23	Full-Featured 8/14-Pin Microcontrollers	1	Microchip
2	B01MR569GA	POTEK 500W Inverter	1	Amazon
3	TMP36	KOOKIE 5PCS Temperature Sensors TMP36 Precision	1	Mouser
4	333141268137	8mm LED Indicator Warning Signal Light Thread Metal 3V 6V 9V 12~220V Panel Mount	3	Ebay

5	EPTTECH FS-IR1901D	Optical Infrared Water Oil Liquid Tank Agriculture Irrigation Level Sensor Switch Food Safety, Come with 500mm Cable	1	Amazon
6	AutoCraft U1-1 Battery	AutoCraft U1-1 Lawn and Garden 160CCA Battery	1	Walmart/Advance Auto Parts

Inverter Choice:

Project Goal *Finding an efficient and affordable Power Inverter*	Each Item ranked using the 1-5 Scale as indicated below						
	Very Low (less good)		Moderate		Very High (best)		
	1	2	3	4	5		
INVERTER TYPE	Effeciency	Operating Temperature	Review	Cost	Durability	**Total Score**	**Implement? Yes/No**
Weighted Criteria	**10**	**9**	**8**	**7**	**5**		
BESTEK 500W	4	5	4	5	5	*177*	Yes
BESTEK 300W	4	5	4	5	4	172	No
YINLEAD 800W	3	4	3	5	4	145	No
KYXN 300W	3	4	4	3	5	144	No
BESTEK 400W	4	5	4	4	5	170	No
POTEK 500W	4	5	4	5	5	177	Yes

Using the above solution selection Matrix, we will choose either BESTEK 500W inverter or POTEK 500W as both score the highest. The POTEK 500W Inverter is cheaper so we will be going with that one

for now. The POTEK 500W was rated 5 stars by many users when compared to the other inverters and it has an 18-month manufacturer warranty which means it is durable.

https://www.potekelec.com/product/288/500w-power-inverter-red

Microcontroller Choice:

Solution Selection Matrix

Project Goal *Finding an efficient and affordable Power Inverter*	Each Item ranked using the 1-5 Scale as indicated below						
	Very Low (less good)		Moderate		Very High (best)		
	1	2	3	4	5		
MICROCONTROLLER TYPE	Effeciency	Operating Temperature	Review	Cost	Durability	**Total Score**	**Implement? Yes/No**
Weighted Criteria	10	9	8	7	5		
microprocessor 8085	5	5	4	5	5	*187*	No
DAQ Microcontroller	2	5	2	1	4	108	No
silicon lab microcontroller	3	4	3	1	4	117	No
8 bit Microcontrller- MCU 8-Bit MCU 3.5k flash 128 RAM 32MHz OSC	3	4	4	5	5	158	No
PIC16F15323-I/P(14-PIN PDIP, SOIC, TSSOP	5	5	4	5	5	187	Yes
PIC16F15323-I/P(16-PIN UQFN (4X4))	5	5	4	5	3	177	Yes

Using the above selection matrix, we choose PIC16F15323-I/P 14 PIN, as it's easy to use with the debugger and can be easily mounted in the PCB layout without the need of transferring the programing to another chip the

same chip can be used in programming and in the circuit. It's going to eliminate the need for DAQ because all the sensors used in the project are analog and it needs to be converted from analog to digital to make the PIC read the value. This Pic meets the criteria for durability as it can last for a long time.

Temperature Sensor Choice:

Project Goal *Finding an efficient and affordable Temperature Sensor*	Each Item ranked using the 1-5 Scale as indicated below						
	Very Low (less good)		Moderate		Very High (best)		
	1	2	3	4	5		
TEMPERATURE TYPE	Life	Operating Temperature	Review	Cost	Durability	Total Score	Implement? Yes/No
T	10	9	8	7	5		
TMP36	5	4	5	5	4	*181*	Yes
DHT11	5	4	3	4	3	153	No
TMP100AQDBVRQ1	5	4	4	3	4	159	No
DHT12	5	4	4	3	3	154	No
TMP235AQDCKTQ1	4	4	3	5	3	150	No
MCP9510HT-E/CHVAO	4	4	3	5	3	150	No

The microcontroller we have wasn't able to read the data from DHT11, it was able to read from Arduino when we tested it. Because of that we changed the plan to an analog sensor.

https://www.amazon.com/gp/product/B01GH32AQU/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1

LED Sensor Choice:

Project Goal *Finding an efficient and affordable LED Sensor*	Each Item ranked using the 1-5 Scale as indicated below						
	Very Low (less good)		Moderate		Very High (best)		
	1	2	3	4	5		
LED SENSOR TYPE	Low Power Consume	Operating Temperature	Review	Cost	Durability	**Total Score**	**Implement? Yes/No**
Weighted Criteria	10	9	8	7	5		
8mm LED Indicator Warning Signal Light Thread Metal 3V 6V 9V 12~220V Panel Mount	5	4	5	5	4	*181*	Yes
558-0102/0202-023F	5	4	4	4	4	166	No
3mm 5mm 8mm 10mm Pre Wired LED + Holder DC9-12V Color Lights Emitting Diodes	3	4	5	3	4	147	No
3mm 6v Pre-Wired Red/Pure Green LED - Ultra Bright (3v, 4v, 5v, 6v)	5	4	4	5	2	163	No
Pnl-Mnt Indicators,Recessed,5mm Bi-Color Red/Green LED wWht Diffused,12in. Wire	5	4	4	4	5	171	Yes
5102H1-5V/5102H5-5V	5	4	4	4	3	161	No

Based on the decision matrix above we will be going with the LED sensor 8mm LED Indicator Warning Signal Light Thread Metal 3V 6V 9V 12-220V Panel Mount. We're going to be choosing one green and one red LED that has the voltage 5V6V specifically. We will probably go with the above because the area around the LED looks durable enough and the red LED looks pretty bright when the system is running. In addition, the LEDs are cheap and their operating temperature meets the working environment in Haiti. I can't find out the operating temperature but because of the 99.4% positive feedback for the seller, it probably is not an issue. Also, it is low heat, energy-saving, low power consumption, and has a long service life. The LED we chose is more durable than all the others but it awhile longer to come in.

https://www.ebay.com/itm/8mm-LED-Indicator-Warning-Signal-Light-Thread-Metal-3V-6V-9V-12-220V-Panel-Mount-/333141268137

Liquid Level Sensor:

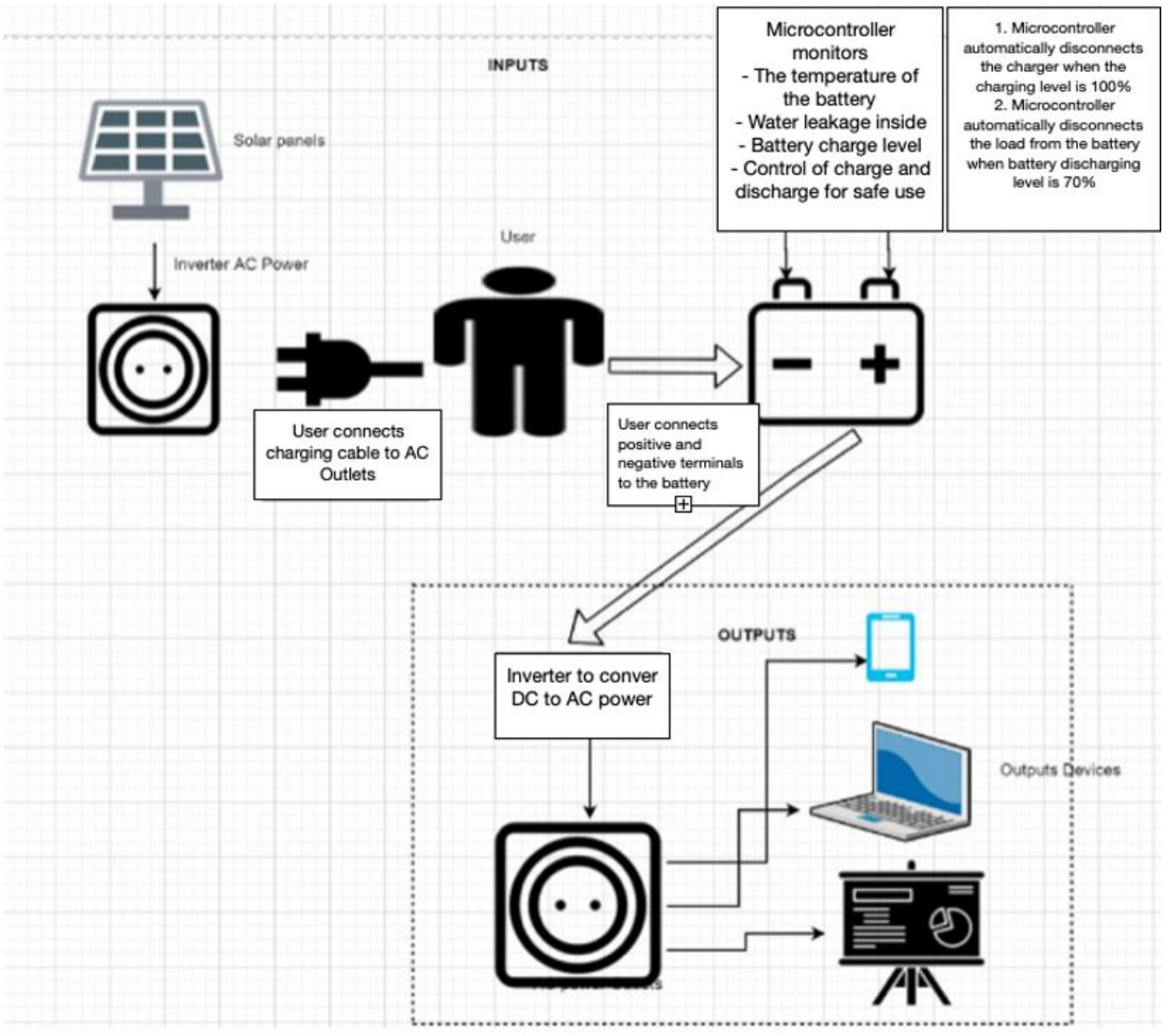
Project Goal *Finding an efficient and affordable Liquid Level Sensor*	Each Item ranked using the 1-5 Scale as indicated below						
	Very Low (less good)		Moderate		Very High (best)		
	1	2	3	4	5		
LIQUID LEVEL SENSOR TYPE	Accuracy	Operating Temperature	Review	Cost	Durability	Total Score	Implement? Yes/No
Weighted Criteria	10	9	8	7	5		
OPB350	3	4	5	5	4	161	No
OPB350L187	4	4	4	5	5	168	Yes
OPB350W062Z	3	4	4	4	5	151	No
OPB350L125	4	4	4	4	5	161	No
EPPTECH WATER LEVEL SENSOR	4	5	5	4	5	*178*	Yes
OPB350L062	4	4	3	5	5	160	No

I was testing the choice for the liquid level sensor and it was giving me a lot of issues. The tube was very small and the sensor was finicky to work with. I feared that even if I got it to work properly that it would be very difficult to test using the PIC so I decided to change it to the EPPTECH Water Level Sensor. It has a lot of good reviews but if I had known the sensor I chose was going to give me such a hard time then I would've bought a much cheaper water level sensor(optical liquid level sensor) on eBay. https://www.amazon.com/gp/product/B0811GRVJH/ref=ppx_yo_dt_b_asin_title_o03_s00?ie=UTF8&psc=1

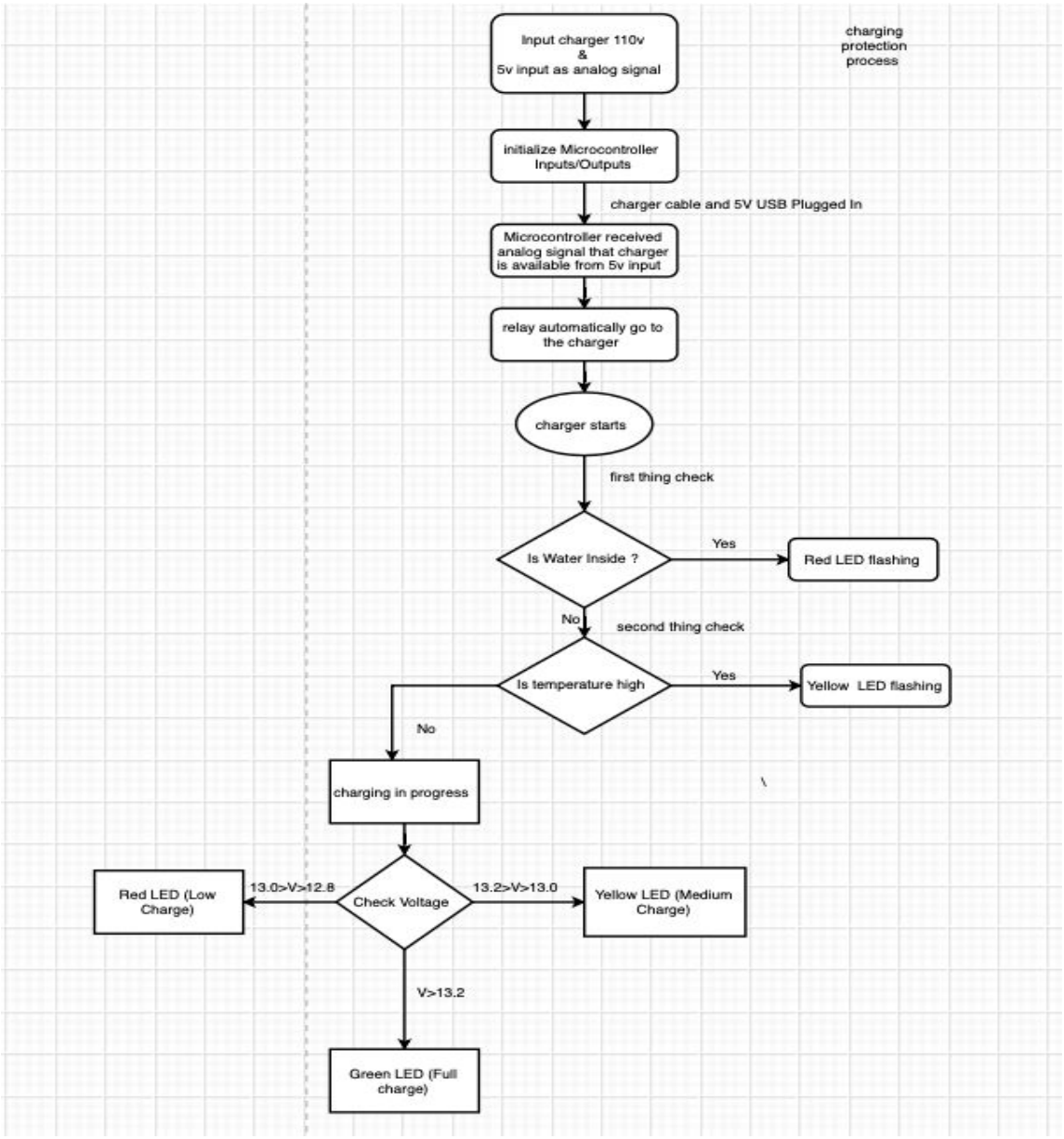
Battery Choice:

We decided to keep the last one because the battery will not be shipped to Haiti and we tested it using a battery tester to see if we can use it for testing purposes. The conditions are: Good(80%-100%) PASS(60%-80%) LOW(40%-60%) FAIL(Less than 40%). The battery is in good condition. The CCA is a rating used in the battery industry to define a battery's ability to start an engine in cold temperatures. The higher CCA, the better the battery is. ENT: 160 CCA ACT: 196 CCA

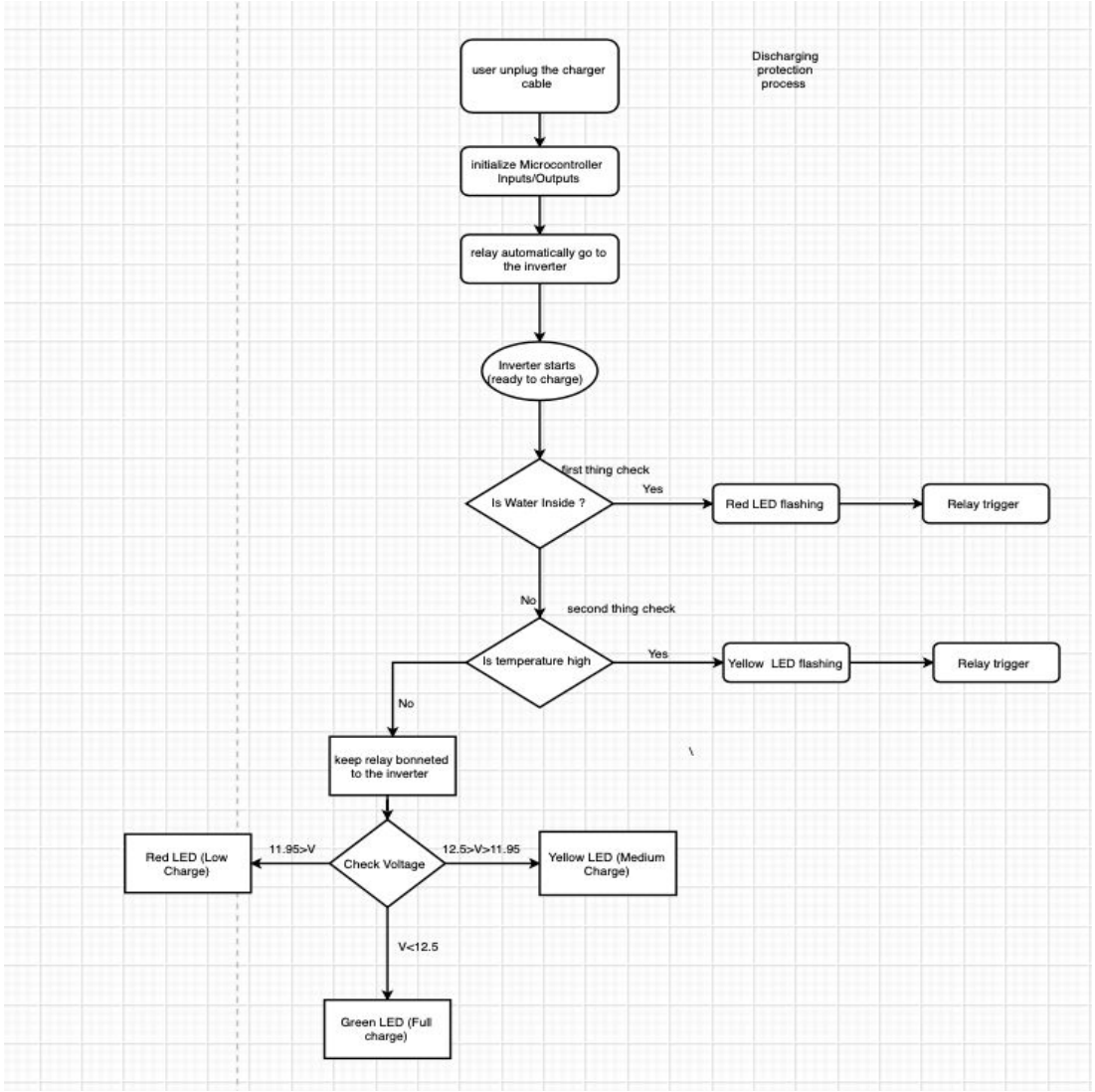
User Interface Design



Software Charging Protection Architecture

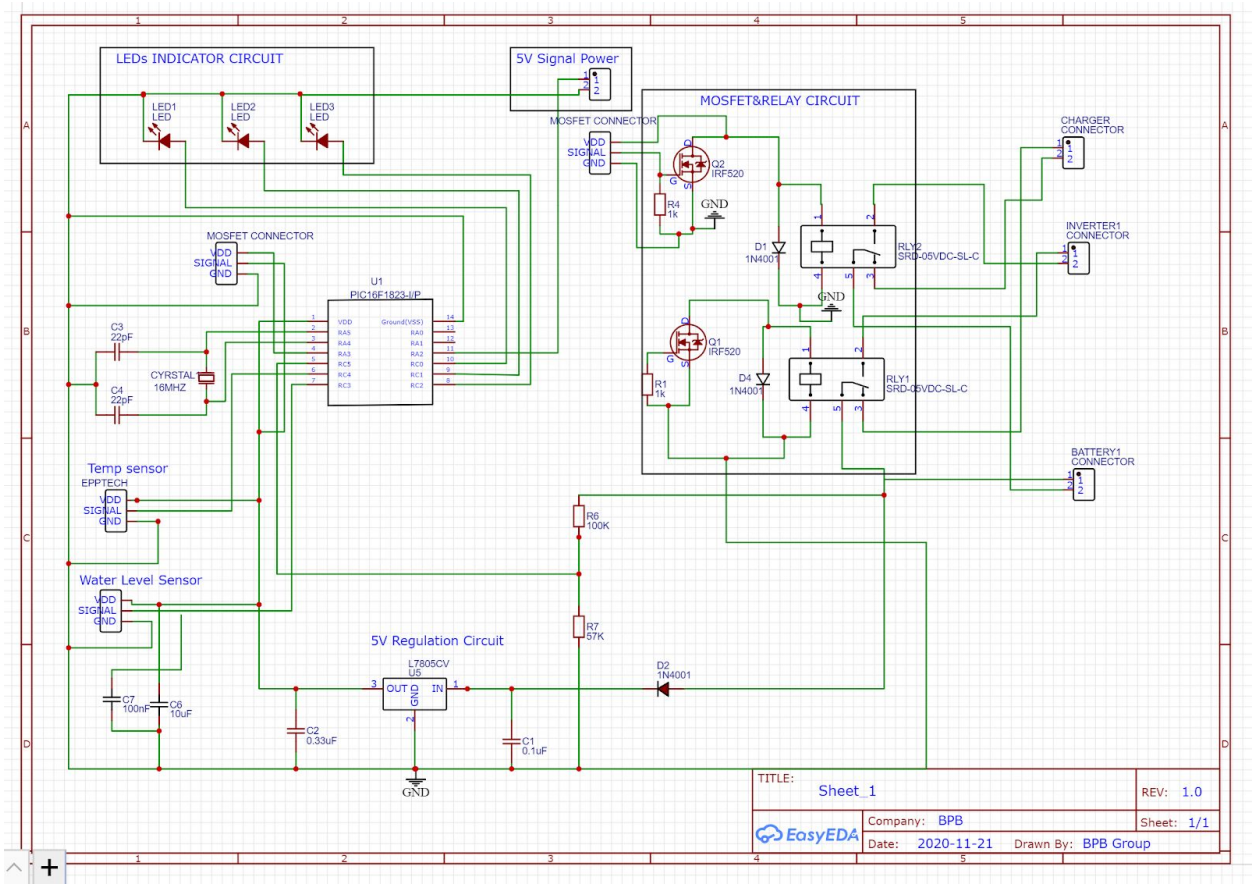


Software Discharging Protection Architecture

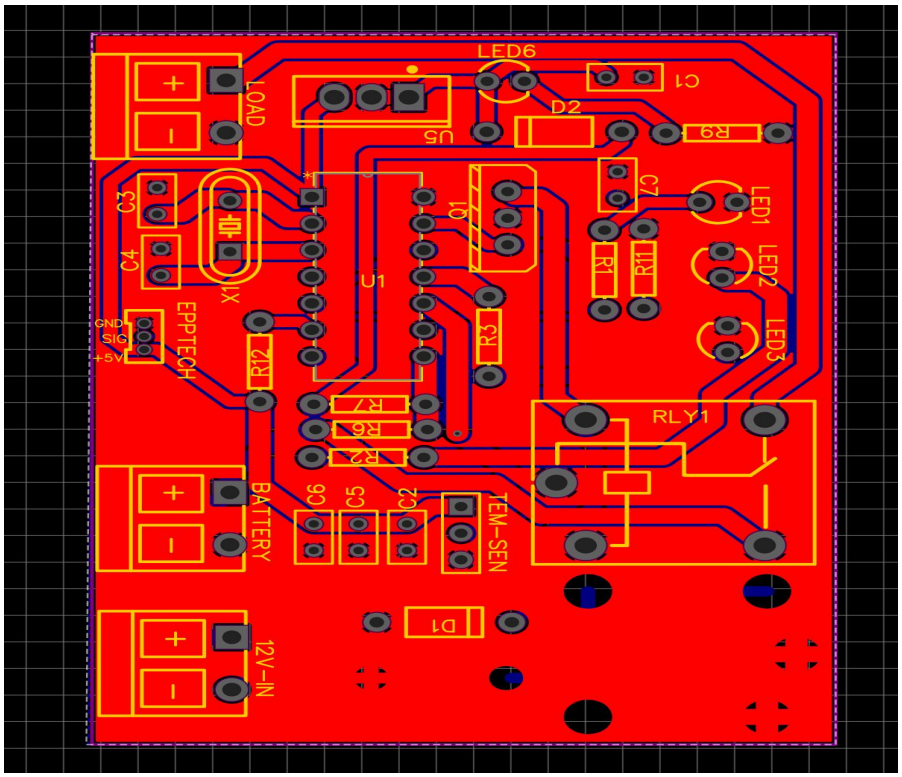


4. LOW-LEVEL DESIGN

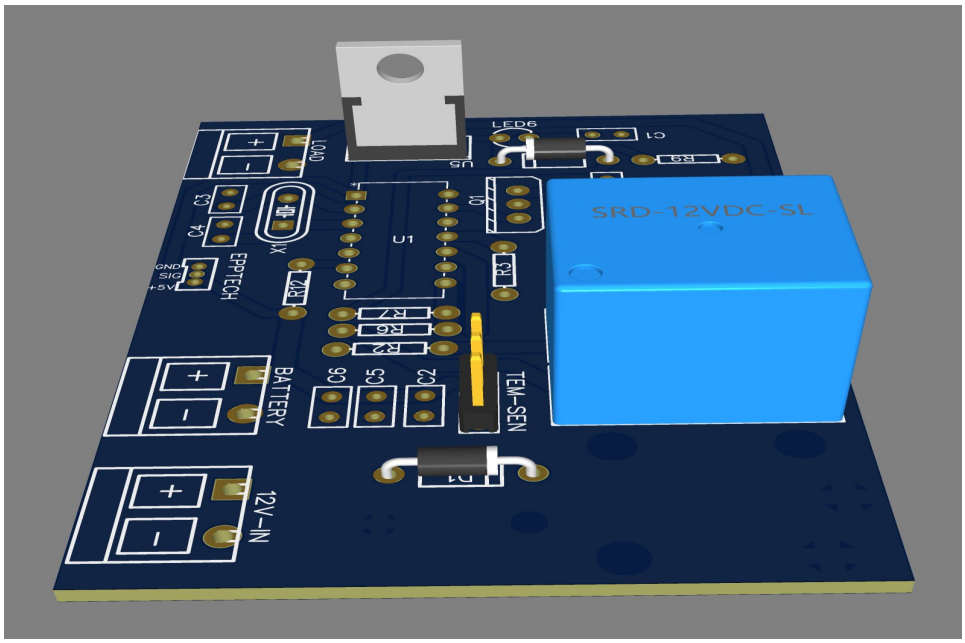
Detailed hardware Assembly (Drawn with EasyEDA):

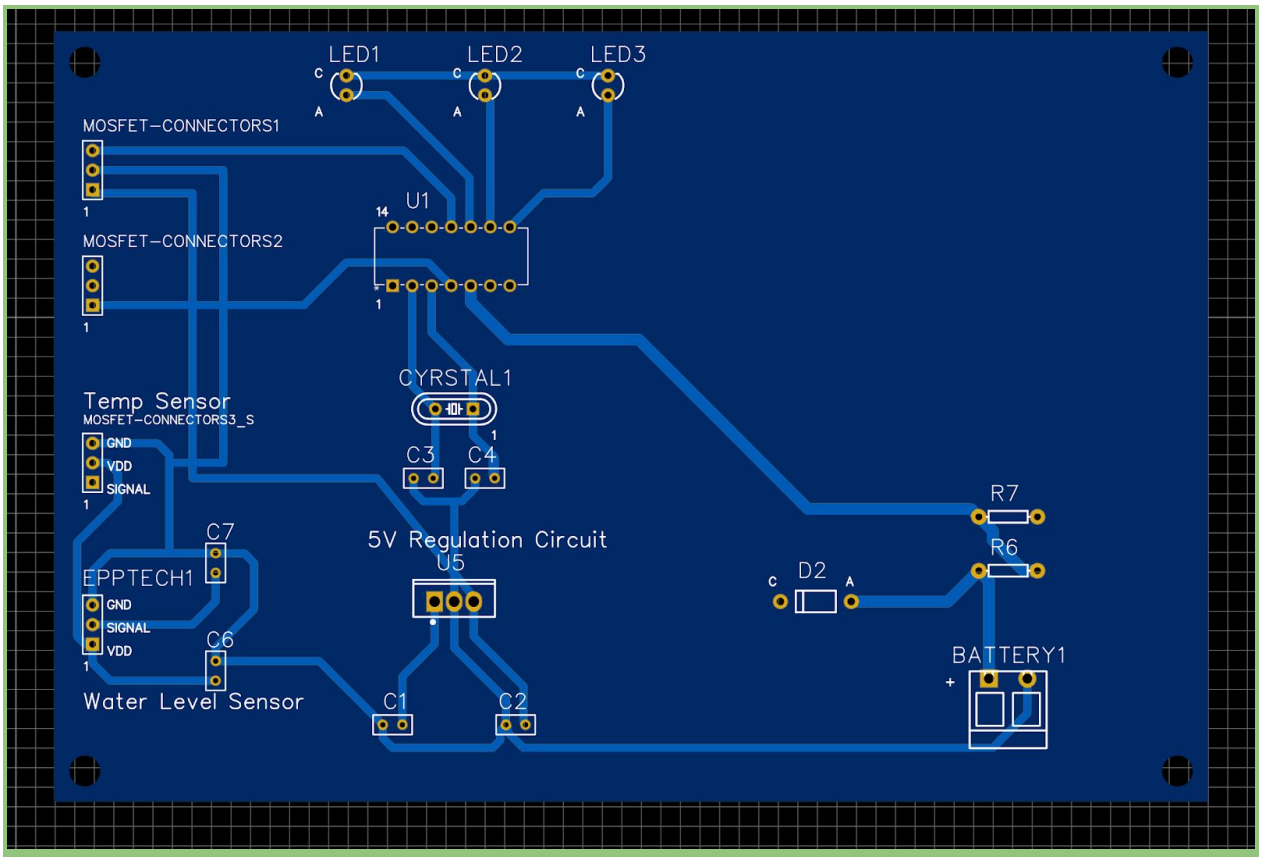


PCB design using EasyEDA Software:

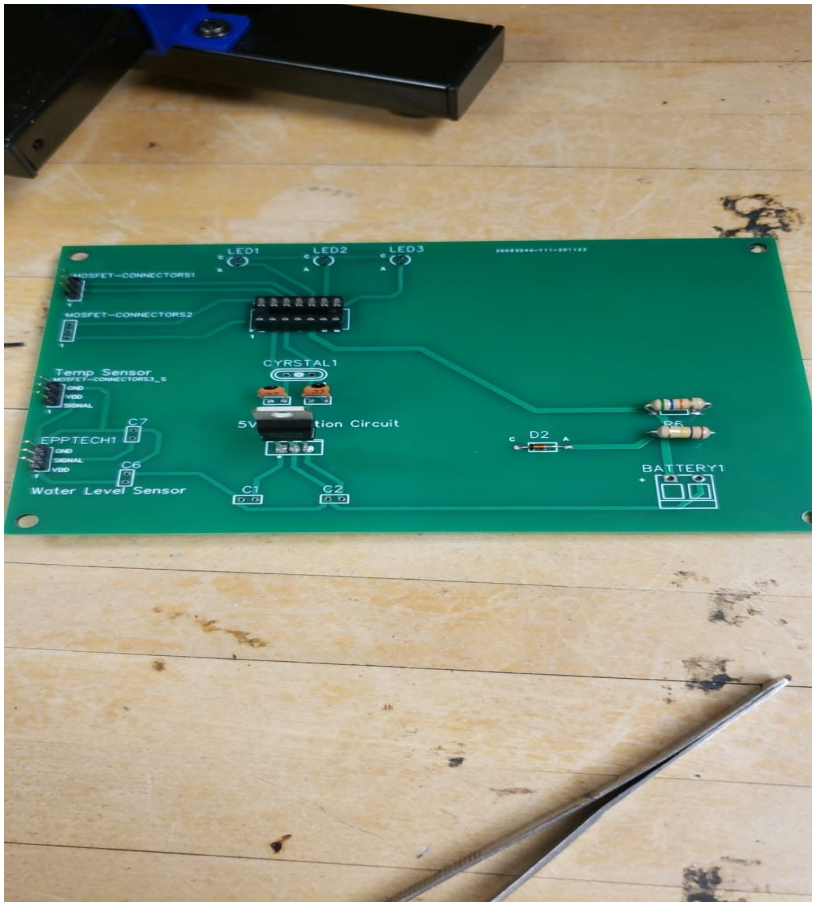


3D View of PCB:



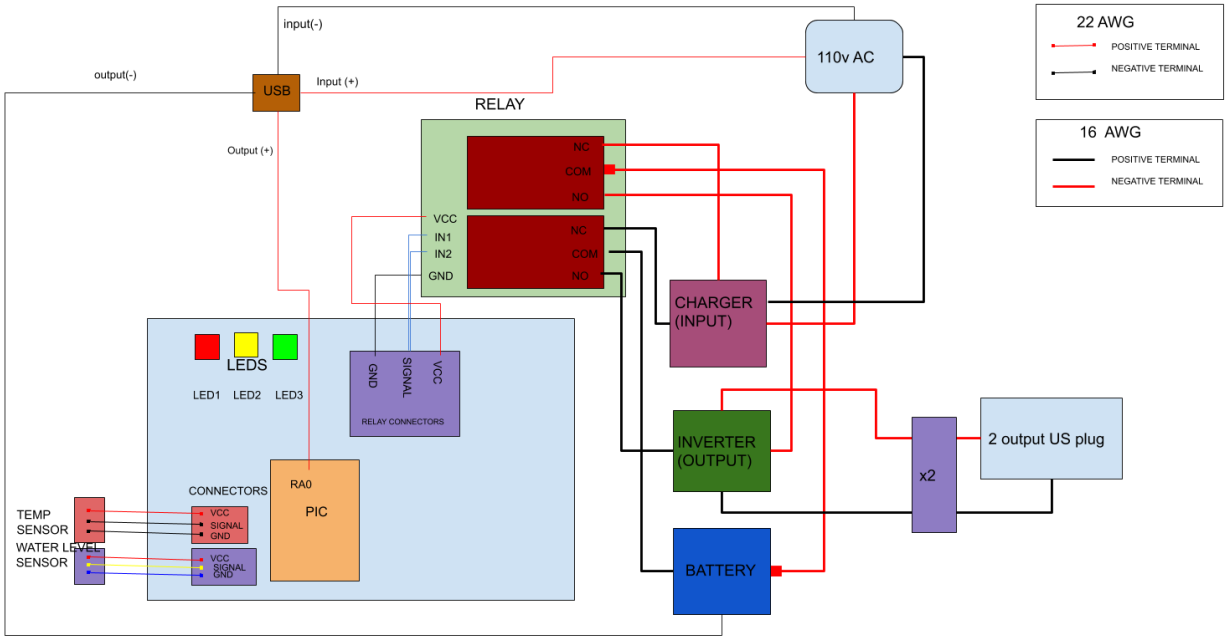

LED1
LED2
LED3
C
A
MOSFET-CONNECTORS1
MOSFET-CONNECTORS2
U1
14
1
CYRSTAL1
Temp Sensor
MOSFET-CONNECTORS3_S
GND
VDD
SIGNAL
C3
C4
R7
R6
C7
5V Regulation Circuit
U5
D2
EPPTECH1
GND
SIGNAL
VDD
C6
BATTERY1
+
Water Level Sensor
C1
C2

PCB Board(without external components added):



BPB Box Setup

BPB Wiring Diagram



Bill Of Materials:

Bill of Materials - Project Name or Drawing Page/Name						
ITEM NO.	MFR Name / PART NO.	QTY.	Price per Unit	Total Price	Description	
1	PIC16(L)F15313/23-I/P	1	$0.84	$0.84	8-bit Microcontrollers	https:
2	Type B US Plug	2	$0.79	$0.79	10-Amp 125-Volt General-Duty NEMA 1-15r Straight Plug	
3	TO-220 Aluminum Heatsink & Insulator/Mou	1	$0.69	$0.69	WayinTop 10 Packs TO-220 Aluminum Heatsink & Insulator/Mo	https:
5	HiLetgo 2pcs DC 12V 2 Channel Relay Module	1	$6.99	$6.99	Optocoupler High and Low Level H/L Level Trigger Module Triggered by DC 12V	https:
6	IC 7805 Voltage Regulator	1	$0.50	$0.50	5V Voltage Regulator	https:
7	16 MHZ cyrstal	1	$0.60	$0.60	Uxcell	https:
	100k resistor	1	$0.10	$0.10	values so the current going to the PIC will be low enough to not destroy the PIC	https:
8	57k Resistor	1	$0.10	$0.10	resistors for voltage sensor, to protect the PIC by adjusting the current to be low enough to not destroy the PIC	https:
9	22pf capacitor	2	0.1	0.2	Provide voltage stability to the 16 MHZ cyrstal	https:
10	Diode	1	0.18	0.18	Protect the circuit - control current flow in one direction	https:
11	8 mm LED Indicator 5V6V Green	1	1.74	1.74	Indicates state of charge	https:
12	Plugin Receptacle	2	17.97	35.94	journeyman-pro 5279 - plugin receptacle w/ front cover	https:
13	EPTTECH FS-IR1901D Optical Infrared Water Level Sensor	1	12.9	12.9	EPTTECH FS-IR1901D Optical Infrared Water Oil Liquid Tank A	https:
14	TMP36	1	1.5	1.5	Temperature Sensor TMP36 Precision Linear Analog Output	https:
15	POTEK 500W Inverter	1	33.99	33.99	Convert DC to AC	https:
16	12V U1 Battery EverStart	1	24.87	24.87	EverStart Lead Acid Lawn and Garden Battery	https:
18	Battery Charger	1	36.99	36.99	Adakiit 6/12V 4A Smart Battery Charger	https:
21	24-31 Snap-Top Battery Box	1	8.94	8.94	NOCO HM318BKS Group 24-31 Snap-Top Battery Box For Mar	https:
22	Battery Terminal 5/16"	1	15.99	15.99	5/16" Battery Power & Ground Insulated Stainless Steel Stud	https:
23	16 AWG Wires	1	6.95	6.95		https:
24	0.1uf Ceramic Capacitor	1	0.38	0.38		https:
25	2.54mm Male Pin Header Connector Strip 3	10	6.99	6.99		https:
26	extension cord	1	2.95	2.95		https:
27	usb cable	1	1.89	1.89		https:
28	8mm LED Indicator 5V6V Yellow	1	1.74	1.74	Indicates state of charge	https:
29	Electrical tape	1	3.98	3.98	safety vinyl electrical tape	https:
30	usb ac dc power adaptor	1	1.75	1.75		https:
31	22 AWG Wires	1	8.99	8.99		https:
32	0.33uf Ceramic Capacitor	1	0.69	0.69		https:
33	10uf Ceramic Capacitor	1	0.5	0.5		https:
34	100nf Ceramic Capacitor	1	1.2	1.2		https:
35	8mm LED Indicator 5V6V Red	1	1.74	1.74	Indicates state of charge	https:
	Total			223.6		

Websites(for materials):

Pic16- https://www.microchip.com/wwwproducts/en/PIC16F15323 (Package Type: PDIP; Temp Range:-40C to +85C; Packing Media: Tube)

TO-220 Aluminum Heatsink- https://www.amazon.com/gp/product/B081GRZB6S/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1

2 channel relay module- https://www.amazon.com/HiLetgo-Channel-Isolated-Optocoupler-Trigger/dp/B00LW15F42/ref=sr_1_3?dchild=1&keywords=12V+DC+spdt+relay+2+channel&qid=1602746674&sr=8-3

Voltage Regulator- https://www.mouser.com/ProductDetail/STMicroelectronics/L7805CV?qs=9NrABl3fj%2FqplZAHiYUxWg%3D%3D

16 MHZ crystal- https://www.ebay.com/p/1139148634

100k resistor-https://www.digikey.com/en/products/detail/yageo/CFR-12JB-52-100K/3950?gclid=CjwKCAiAq8f-BRBtEiwAGr3DgSc--tN-VQkYjfsYUMFJPPGH-VMrmvpeKmSrhnezXzYGorOnxhnTXRoCEH4QAvD_BwE

57k resistor-https://www.digikey.com/en/products/detail/yageo/MFR-25FBF52-57K6/13426

22pf capacitor-https://www.digikey.com/en/products/detail/trigon-components/CCD-207S220JK72/13236859

Diode-https://www.mouser.com/ProductDetail/Vishay-Semiconductors/BZX55C22-TR?qs=8Acm1RElxHJZdhFfB4FdIw%3D%3D&gclid=CjwKCAiAq8f-BRBtEiwAGr3DgWIjERA-SR4GL96b7m3DimWyhbMQ8QXMEq-jEaqIW5gvSNBgZ5YbnBoCiXoQAvD_BwE

Green led indicator-https://www.ebay.com/itm/8mm-LED-Indicator-Warning-Signal-Light-Thread-Metal-3V-6V-9V-12-220V-Panel-Mount/333141268137?var=542163624323&hash=item4d90c456a9:g:VgkAAOSwk2JcosHS

Plugin receptacle- https://www.amazon.com/Journeyman-Pro-120-125-Commercial-Straight-Receptacle/dp/B07MSGGNM8/ref=sr_1_1?dchild=1&keywords=journeyman-pro%2B5279%2B-%2Bplugin%2Breceptacle&qid=1590965692&sr=8-1&th=1

Epptech water level sensor-https://www.amazon.com/FS-IR22-Optical-Infrared-Agriculture-Irrigation/dp/B07BFP8ZLS

tmp36-https://www.mouser.com/ProductDetail/SparkFun/SEN-10988?qs=WyAARYrbSnbEB8w%252BWb%252BmnQ%3D%3D

Potek 500w inverter-https://www.amazon.com/POTEK-Power-Inverter-Charging-Laptop/dp/B01MR569GA

Battery 12v-https://www.walmart.com/ip/EverStart-Lead-Acid-Lawn-Garden-Battery-Group-Size-U1-12-Volt-230-CCA/21984263

Battery charger-https://www.amazon.com/dp/B07ZCXDQSP/ref=cm_sw_r_wa_apa_i_1le1Eb1K2MM09

Snap top battery box-https://www.amazon.com/NOCO-HM318BKS-Snap-Top-Automotive-Batteries/dp/B004W5SGBO/ref=sr_1_1?dchild=1&keywords=noco+battery+box&qid=1605896561&sr=8-1

Battery terminal-https://www.amazon.com/Battery-Ground-Insulated-Stainless-Junction/dp/B07B44F4ZW/ref=sr_1_2?dchild=1&keywords=UTSAUTO+Battery+terminal+5%2F16%27%27+stud&qid=1591188776&s=automotive&sr=1-2

16 AWG Wires-https://www.amazon.com/American-Aluminum-Primary-Amplifier-Available/dp/B07D73ZRDP/ref=sr_1_2?dchild=1&keywords=16+awg+cca&qid=1607638225&sr=8-2

0.1uf capacitor-https://www.digikey.com/en/products/detail/kemet/C322C104M5R5TA/3726176

2.54mm Male Pin Header Connector Strip 3 Position-https://www.ebay.com/itm/3M-929400-Tin-2-54mm-Male-Pin-Header-Connector-Strip-3-Position-Pack-of-10/223087722182?_trkparms=aid%3D111001%26algo%3DREC.SEED%26ao%3D1%26asc%3D225086%26meid%3D75caed3e82854c4a96902a4788205a5d%26pid%3D100675%26rk%3D4%26rkt%3D15%26mehot%3Dnone%26sd%3D112352928342%26itm%3D223087722182%26pmt%3D0%26noa%3D1%26pg%3D2380057%26brand%3D3M&_trksid=p2380057.c100675.m4236&_trkparms=pageci%3A76cad4ca-3b3d-11eb-b25e-061d90777d72%7Cparentrq%3A4eef4a311760ace085dba548fffe2634%7Ciid%3A1

Extension cord-https://www.beeslighting.com/93-192?keyword=%7bbkeyword%7d&creative=%7bbcreative%7d&gclid=CjwKCAiA8Jf-BRB-EiwAWDtEGs8G6KJB6gWUTBCl8JkDtZnZMfjr8PjRRNjYH3Gn76fA9Bzcph98sBoCCOoQAvD_BwE

Usb cable-https://www.ebay.com/itm/313278939185?mkevt=1&mkcid=28&chn=ps

Yellow led indicator-https://www.ebay.com/itm/8mm-LED-Indicator-Warning-Signal-Light-Thread-Metal-3V-6V-9V-12-220V-Panel-Mount/333141268137?var=542163624323&hash=item4d90c456a9:g:VgkAAOSwk2JcosHS

Electrical tape-https://www.amazon.com/gp/product/B00004WCCL/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1

Usb ac dc power adaptor-https://www.ebay.com/i/193240017884?chn=ps&mkevt=1&mkcid=28

22 AWG Wires-https://www.amazon.com/65-6ft-Extension-JACKYLED-Strips-Single/dp/B00QTCBZ4I/ref=sr_1_4?dchild=1&keywords=22+awg+wire&qid=1607638342&sr=8-4

Red led indicator-https://www.ebay.com/itm/8mm-LED-Indicator-Warning-Signal-Light-Thread-Metal-3V-6V-9V-12-220V-Panel-Mount/333141268137?var=542163624323&hash=item4d90c456a9:g:VgkAAOSwk2JcosHS

0.33uf ceramic capacitor-https://www.digikey.com/en/products/detail/tdk-corporation/FA24X7S2A334KRU06/9560774

10uf ceramic capacitor-https://www.digikey.com/en/products/detail/tdk-corporation/FG28X5R1E106MRT00/7384816

100nf ceramic capacitor-https://www.digikey.com/en/products/detail/tdk-corporation/FA26C0G2A104JRU06/8343842

5. Testing Methodology & Test Results:

Battery Testing-

1. Begin initial testing in a lab while wearing gloves and eye protection(face shield)
2. Connect the positive and negative leads of the battery tester to the battery correctly
3. Input the CCA(cold cranking amps) into the battery tester
4. Monitor the battery tester screen for a good(80%-100%) or pass(60%-80%) condition
5. If it is neither the cell has gone bad and should be replaced
6. If it passes begin charging the battery while monitoring its voltage

Battery Test Results-

The results are that the battery is in a good condition and that we don't need to buy another to test our system.

BulletProof Battery System Testing-

1. Begin initial testing in a lab while wearing gloves and eye protection(face shield)
2. Begin initial testing in a fully charged state. (Battery capacity maximized by trickle charger). Record this value
3. Ensure the leads on the battery are firmly attached to lead cables in the BBP.
4. Connect it to the rest of the system. LEDs should illuminate to show the power-up/battery charge level. Confirm this happens & record
5. Ensure that when the battery is fully charged that the relay switches to connect the battery to the system instead of the charger.
6. Check and record the outbound voltage. (should be approximately 110VAC).
7. Plug in a laptop/projector to the BBP and it should power on. (record)
8. Keep the BBP connected to the laptop/projector until it can no longer power it. (record)
9. The BBP should shut off outbound power at the moment the battery reads 12.4 VDC. (Check battery voltage and record within 5 minutes of the device no longer being powered).
10. The system should notify the system that it needs charging and flip the relay itself to allow the battery to connect to the charger. The system should not acknowledge charging status via LEDs but by measuring the battery voltage itself. (record)
11. The LEDs should indicate when it is low and needs charging.

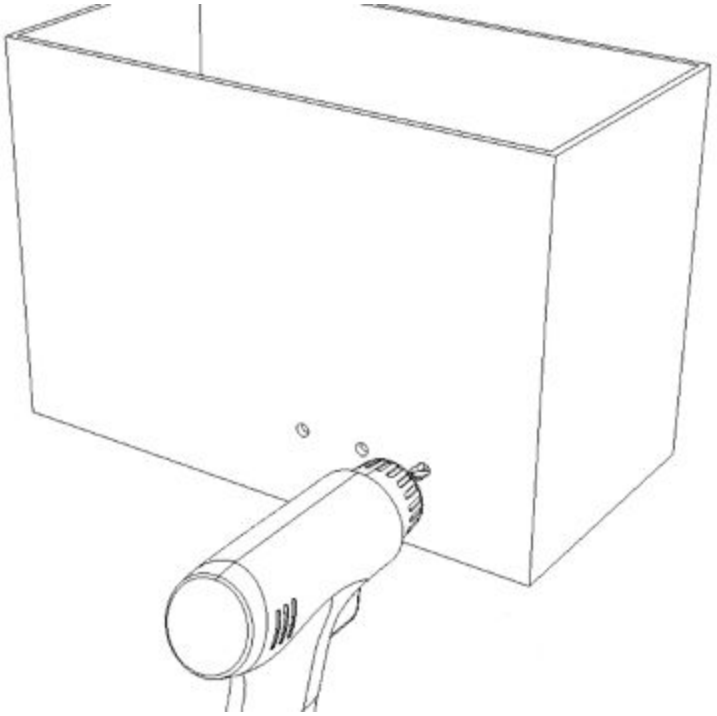
12. Once the battery has reached a peak charge (Approximately 13.7 VDC), record the peak charge and leave the charger on for a longer period of time. The BBP should no longer show charging (visible through LED's). Check Battery Voltage and Record.
13. When the BBP system is all hooked up, the Battery level should be displayed, but no charging or Power out should be capable. Ensure this occurs and record.
14. Water Level sensor to be tested in water and out of water. The Water Level sensor should shut off any power or charging when it is submerged in water. Test by placing the bottom of the Water Level sensor in water.
15. Temperature sensor to be tested to overheat using the hairdryer, to cold using ice. The temperature sensor should not allow operation below 0 C & above 50 C.

Battery System Testing Results-

The results are that the system is working perfectly fine. We had some delays with testing the circuit on the pcb board but after some configurations it works the same as it does on the breadboard. Charging the battery takes around 5 hours and discharging the battery takes around 2 to 3 hours based on the multiple tests that were conducted to make sure the system is working as intended

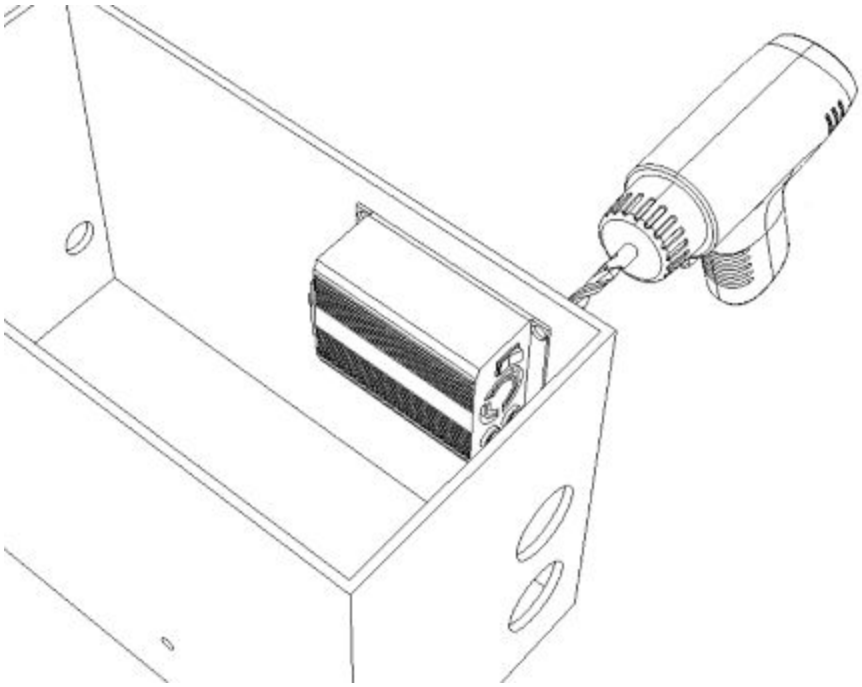
Mechanical layout:

- Drilling outside the Box

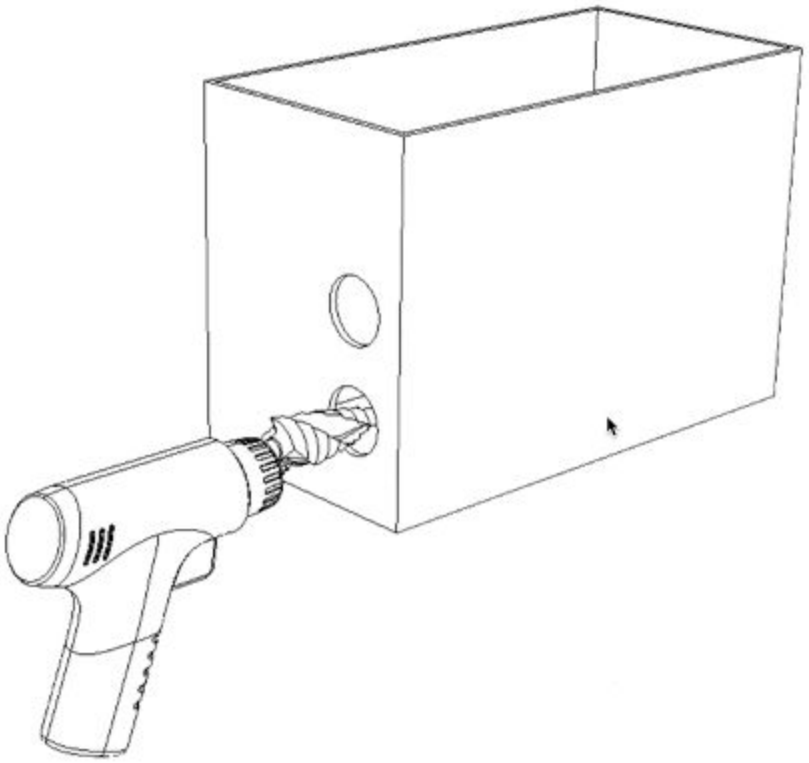


1. 3 holes for 3 different LEDs (5/16 inch drill or 8mm)

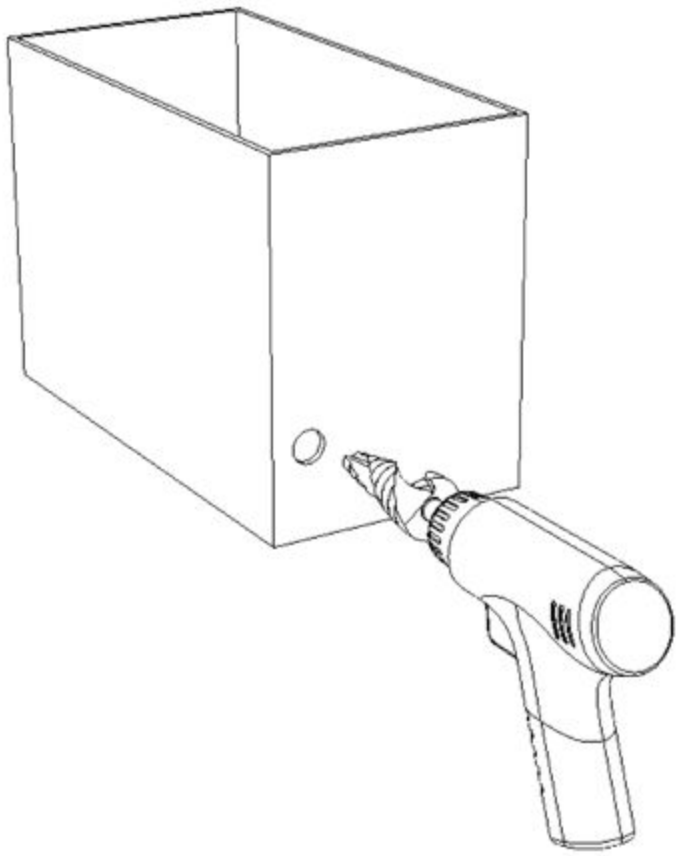
2. 4 holes for inverter



1. 2 holes for users to charge and power their products from inverter



2. One hole for charger cable



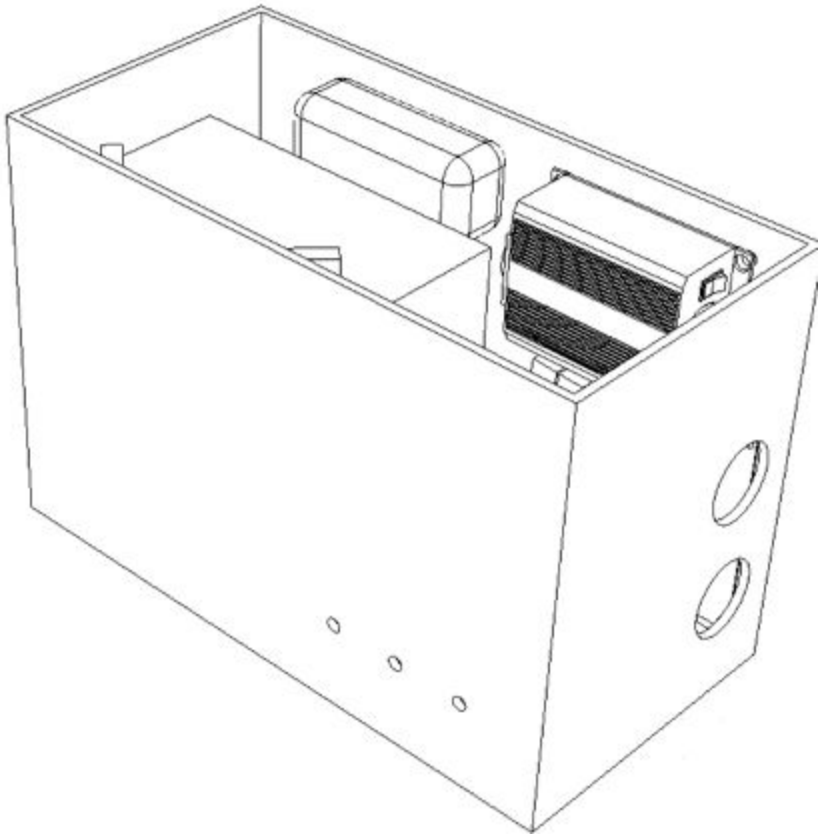
Note:

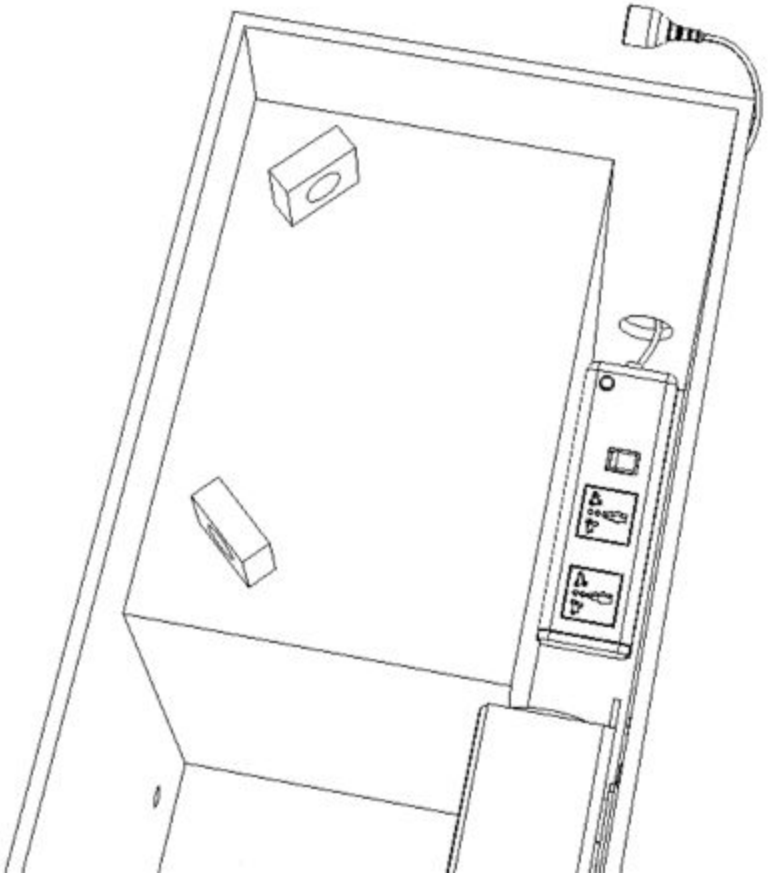
When drilling the inverter plug it should not be in the back of either inverter or charger for the safety

- Inside the Box

Note: for the battery and charger we recommend using strong double sided tape to hold it steady.

Note: when placing the PCB Board water level sensor should be placed near by the battery to protect it





- Assembly instructions

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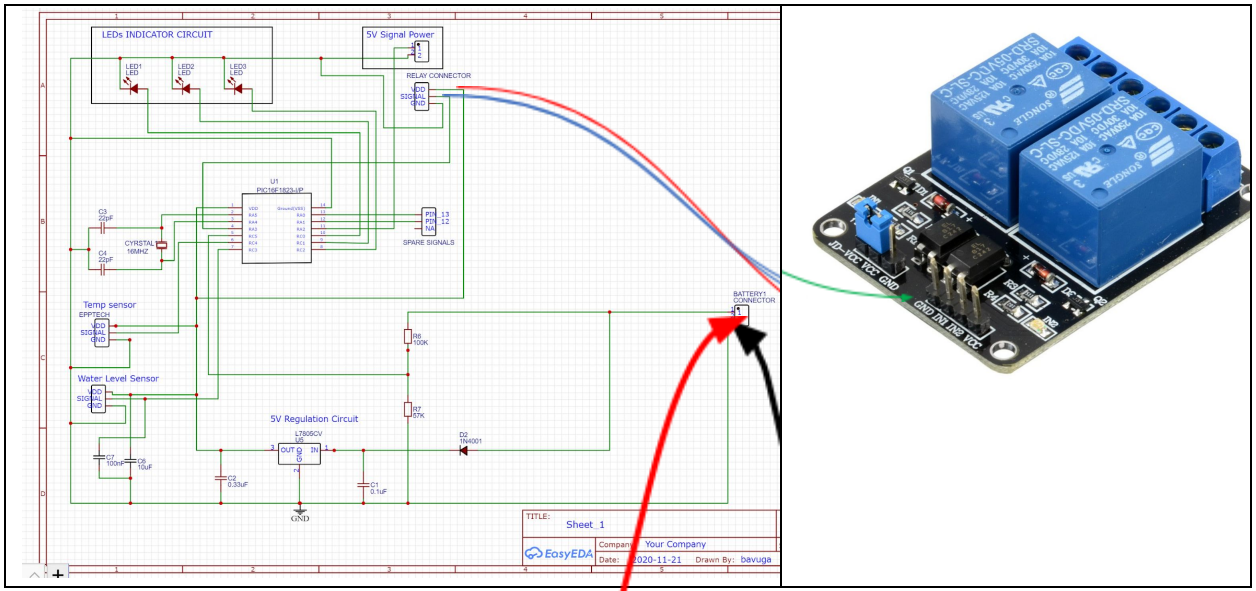
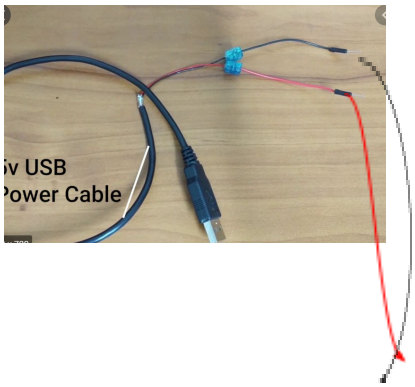
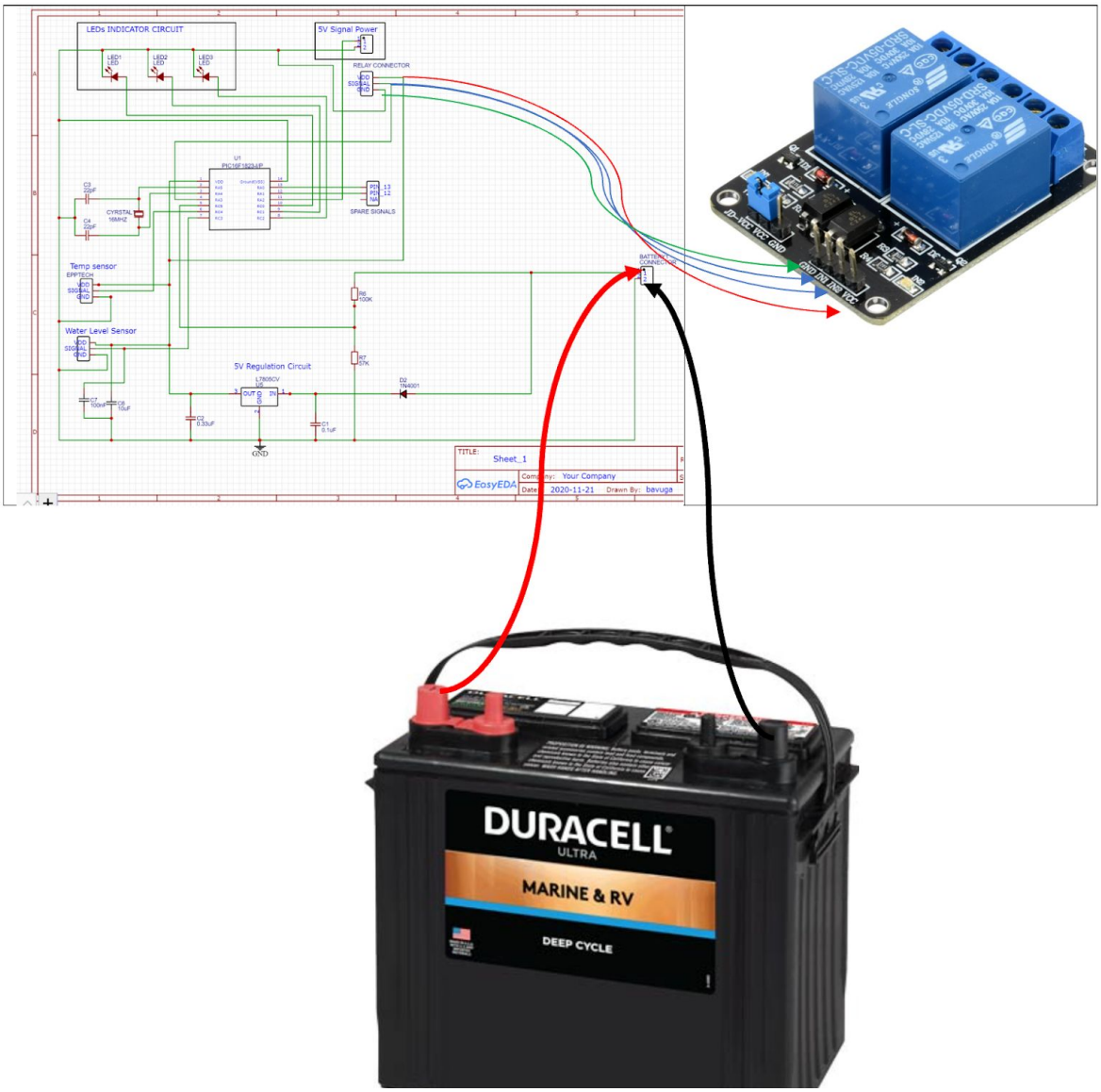
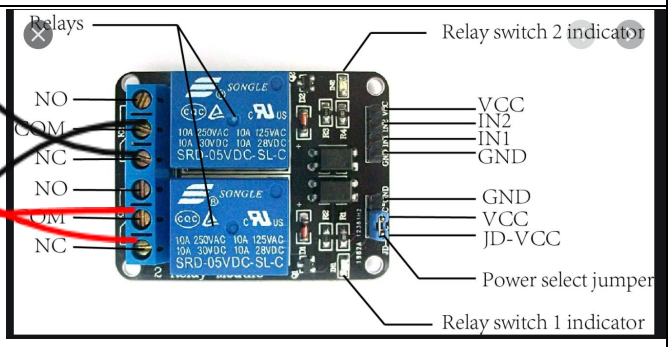



DURACELL
ULTRA
MARINE & RV
DEEP CYCLE


v USB
ower Cable

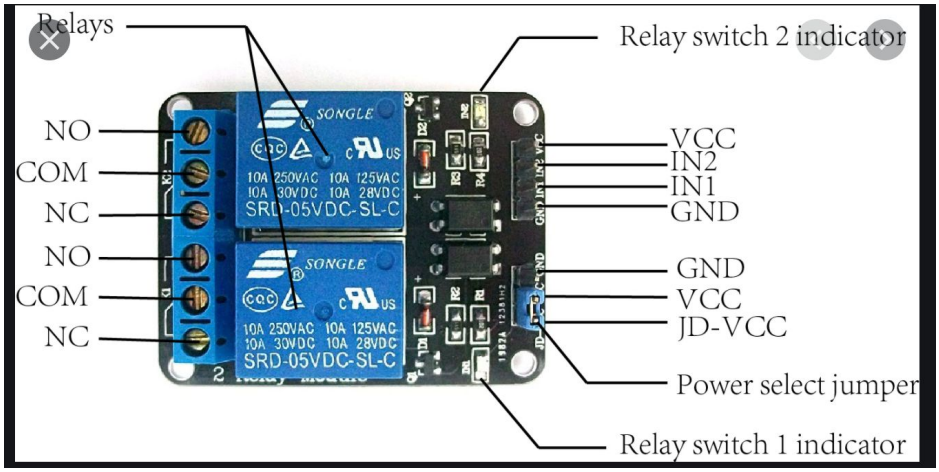


RELAY CONNECTION

<table>
<tr>
<td> 
</td>
<td>Charger
● NC from Relay 1 is connected to Charger Positive
● NO from Relay is connected to Charger Negative</td>
</tr>
<tr>
<td> 
</td>
<td> 
</td>
</tr>
<tr>
<td> 
</td>
<td>Battery
● COMM from Relay is connected to BATTERY Positive terminal
● COMM ON Relay 1 goes to BATTERY Negative terminal

Inverter:
- NC from Relay 2 is connected to Inverter Positive,
- NO from Relay 2 is connected to Inverter Negative</td>
</tr>
</table>

Relay main parts



Note:

- Relay wires need to be connected via screws.

- Everything in the board such as sensors, voltage regulator, resistors, capacitors, LED, PIC needs to be soldered inside the PCB board.
- USB and charger cable needs to be connected via extension cord inside the box.
- Charger cable is the only cable needs to be connected outside the box
- Bolts and nuts for the inverter, Relay and PCB

User Manual In English

BULLET PROOF BATTERY USER MANUAL

Table of Contents

Term	Definition
BPB	Bullet Proof Battery
LED	Light Emitting Diode(Light)

AC Alternating Current

The BPB is a system which protects the battery from overcharging, over-discharging, water, and high temperature. It consists of a battery, an inverter, a battery charger and a microcontroller-controlled circuit which monitors the charging, discharging, water and temperature level of the battery. When the battery is charging, the microcontroller-controlled circuit checks the charge level of the battery and disconnects the battery once the battery is fully charged. The same process happens during discharging, the inverter is automatically disconnected once the voltage level of the battery is at 70% to avoid over-discharging.

Equipment Needed

The BPB encapsulates everything needed for the user to operate the charging and undercharging process. The equipment enclosed inside the system are:

- Battery
- Battery Charger
- Inverter
- LEDs(Lights)
- Relay

- Overcharging, undercharging, water and temperature protection circuit

BPB Installation

Always keep the BPB in an upright position to avoid any acid from leaking out of the battery. Do not shake the BPB. Make sure the connections of the BPB are in good contact with the terminals inside the BPB. Only the charger AC cord, the three LEDs which indicate charge level and the 2 outlets for powering electronic devices are visible from outside.

BPB Charging

The BPB has a charger AC cord which will be connected to the AC outlet wall during charging. Once fully charged, the green LED will turn on. Charge time is 10 hours on a 70% discharged battery or when the red LED turns on. A fully charged battery can power a laptop and projector for up to 2 hours.

BPB Discharging/usage

Once the battery is fully charged the relay switches from charging to discharging. The inverter will automatically be connected to the battery and the user can start powering any device. When the inverter is in use, the green LED or yellow LED will be on and once the battery charging level is 70% the red LED will turn on and the inverter will automatically be disconnected.

LED(Light) Indicators

The BPB has three LEDs attached to the outside of the box. They are green, yellow and red respectively. The green LED on indicates the battery is fully charged, the yellow LED on means the battery is above 70% charged, the red LED being turned on means the battery needs to be charged, and the red LED flashing means the polarity isn’t correct/flood or temperature limit was hit.

BPB Cleaning

The BPB should be kept clean to avoid the accumulation of dust. Protect the BPB from water going inside to avoid the system from being destroyed/short circuited. Keep the BPB clean and always store in a cool, dry area. Whenever acid is stored or handled, good ventilation is necessary.

Safety Concerns

If the BPB or battery ever blows up, lights on fire, leaks material, LEDs stop functioning, outlets/charger does not work properly etc. see the technical manual(in English) for further instructions.

Contacts

Chuck Grimm: jongleur34@aol.com

Elaine Cooney: eccooney@iupui.edu

Walla Al-shafie: walshafi@iu.edu

Tiffany Lanteigne: tdlanteigne@gmail.com

Vincent Rutahintare: viruta@iu.edu

- User Manual in French

BPB OPERATOR'S MANUAL

CHARGING

1. CONNECT THE BATTERY CHARGER TO THE POWER SUPPLY (110V~ 60Hz).
2. WAIT AT LEAST 10 HOURS BEFORE DISCONNECTING THE CHARGING CABLE
3. AFTER THE CHARGING PROCESS, DISCONNECT THE CHARGING CABLE.

USAGE/DISCHARGING

1. CONNECT ANY DEVICE CORD TO THE OUTLET FROM THE BOX
2. THERE ARE TWO (2) OUTLETS ON THE BOX, CONNECT TO ONE IF YOU HAVE ONE DEVICE OR USE IF YOU HAVE 2 DEVICES.

THE BATTERY WILL GENERALLY LAST UP 2 HOURS WHEN USING A LAPTOP AND A PROJECTOR, BUT IF THE BATTERY LEVEL IS 12.4V, THE SYSTEM WILL AUTOMATICALLY SHUT DOWN AND NO POWER WILL BE AVAILABLE IN THE OUTLET.

RECHARGE THE BATTERY REGULARLY EVEN IF IT IS NOT COMPLETELY DISCHARGED.

IN FRENCH

MISE EN CHARGE

1. LE CHARGEUR DE BATTERIE AU PRISE ÉLECTRIQUE (110V˜60Hz).

2. ATTENDEZ AU MOINS 10 HEURES AVANT DE DÉCONNECTER LE CÂBLE DE CHARGE

3. APRÈS LE PROCESSUS DE CHARGE, DÉBRANCHEZ LE CÂBLE DE CHARGE.

UTILISATION / DÉCHARGEMENT

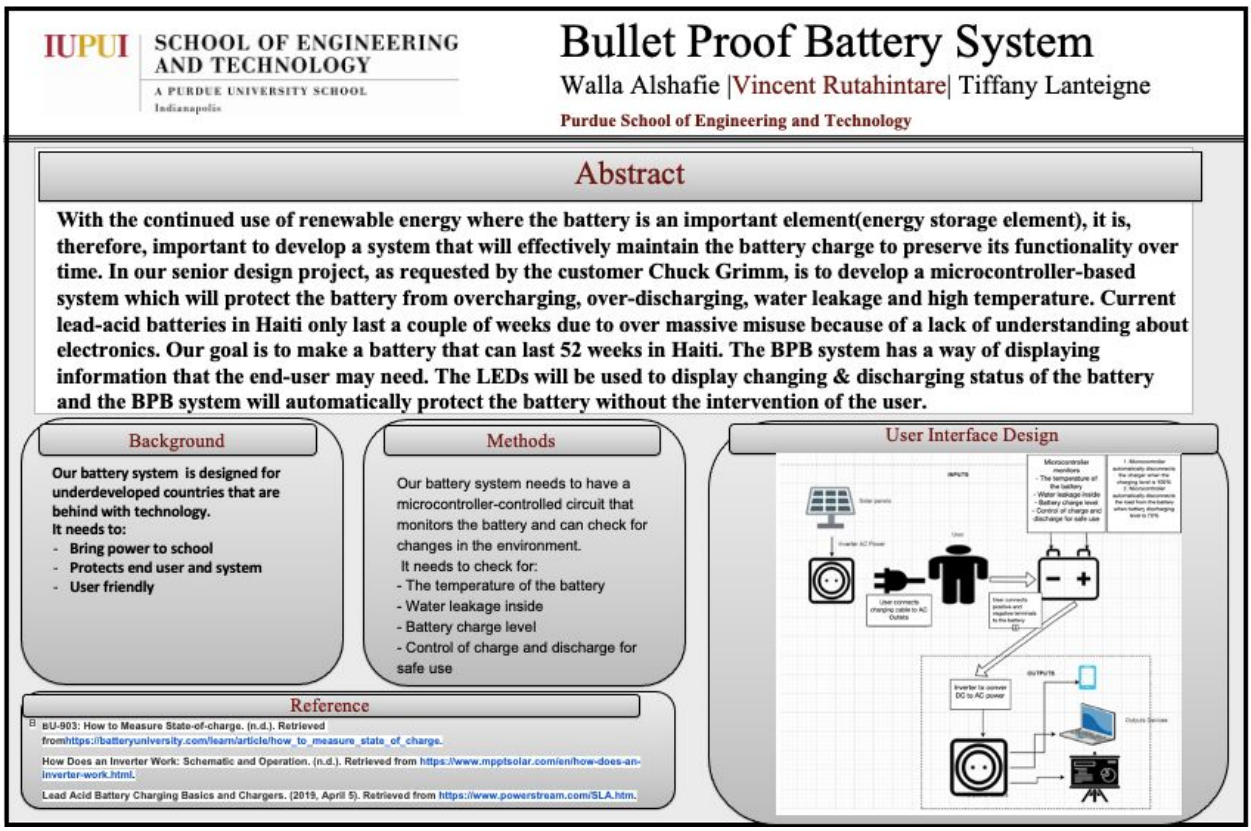
1. CONNECTEZ LE CORDE D'APPAREIL D’ UTILISATION AU PRISE SITUÉ SUR LA BOÎTE

2. IL Y A DEUX (2) PRISES SUR LA BOÎTE, CONNECTEZ-VOUS SUR L’UNE D’EUX SI VOUS AVEZ UN APPAREIL OU UTILISEZ DEUX PRISES SI VOUS AVEZ DEUX APPAREILS.

LA BATTERIE PEUT DURE GÉNÉRALEMENT JUSQU'À 2 HEURES LORSQUE VOUS UTILISEZ UN ORDINATEUR PORTABLE ET UN PROJECTEUR, MAIS SI LE NIVEAU DE LA BATTERIE EST DE 12,4 V, LE SYSTÈME S'ARRÊTERA AUTOMATIQUEMENT ET AUCUNE ELECTRICITE SERA DISPONIBLE DANS LA PRISE.

RECHARGEZ LA BATTERIE RÉGULIÈREMENT MÊME SI ELLE N'EST PAS COMPLÈTEMENT DÉCHARGÉE.

- POSTER MASTER



6. CONCLUSIONS, RECOMMENDATIONS, AND INDIVIDUAL ASSESSMENT NOTES

6.1 Conclusion

Over the past two semesters we tried and succeeded in improving upon the last team's design for the Bullet Proof Battery System. We simplified the user interface to only give information the end user needs to know, simplified the microcontroller design so as not to draw too much power from the battery, spaced out the circuit board so as not to short circuit the system, made the system cheaper by purchasing simpler parts and added an external usb to the design to let the microcontroller know the 110v charger is plugged in and then the system will switch from discharging to charging. Our system is able to increase the longevity of the battery, decrease human/environmental interference with it's robust enclosure and temperature/water sensor limit capabilities. Our hope is that our design can lead to an increase in the longevity of lead-acid batteries in Haiti and that our system will power devices that can provide an education to the people that live there.

6.2 Recommendations

Some changes could be made to make this system be more flexible and cheaper in design.

Recommended changes:

- Battery box is kinda small even with the small battery that we have. A bigger box could be better if more amp hours is needed. The brand NOCO Snap-Top(same brand we got our box from) has a taller box that could possibly be switched out if the battery that is required is taller in size.
- There are some cheap optical liquid level sensors on ebay that could be purchased for a fraction of the price of the optical liquid level sensor that our team bought but due to time constraints could not.
- Pcb board may be made smaller as long as they do not short circuit the board by having the electrical components too close together.
- Our 16F-PIC that we programmed wasn't C friendly. We had so many difficulties especially when we tried programming the digital sensor, I would recommend using a PIC from another family such as 18F.

6.3 Walla Al-shafie's assessment

As this semester was hard for all of us working together because of the virus. Meeting thru zoom or having messages conversation wasn't enough to communicate. Work division wasn't as it should be if it was a normal semester. At the end all of us learn something new from the project. I personally learn more electrical and programming.

6.4 Tiffany Lanteigne's assessment

With the onset of certain circumstances this project was a struggle to get through and finish. Meeting with fellow teammates proved to be difficult because of restrictions which may have led to serious communication issues along the way. Also because of restrictions issues of division of labor became apparent and was hard to overcome. Perhaps this could have been rectified with more zoom meetings between members instead of other forms of communication which while easier may have led to the problems we greatly suffered from. Though despite the many hardships we faced this semester I think I've learned a lot this past semester. I learned about my weaknesses, improved upon some skills such as soldering, drilling, pcb layout and technical documentation and gained more knowledge about various types of electrical components.

6.5 Vincent Rutahintare's assessment

In this project, I learned a lot. It was a challenging project due to COVID-19 circumstances. The project was mostly done remotely and this was a challenge as the collaboration was very hard to achieve. We communicate with each other as much as we can, but this was not enough to achieve our goal efficiently. I hope that the school will be normal next year as this remote studying is an obstacle to effective learning due to not accessing all the resources a student needs.

References:

BU-903: How to Measure State-of-charge. (n.d.). Retrieved from https://batteryuniversity.com/learn/article/how_to_measure_state_of_charge.

How Does an Inverter Work: Schematic and Operation. (n.d.). Retrieved from https://www.mpptsolar.com/en/how-does-an-inverter-work.html.

Lead Acid Battery Charging Basics and Chargers. (2019, April 5). Retrieved from https://www.powerstream.com/SLA.htm.

Referenced Documents-

Title	Source	Comment
State of Charge Testing Document	Matt Brown & Eric Philbrook	The battery has already been tested by the previous team. It documents the charge/discharge rates of the battery. The battery is not to be driven less than 70% or it will significantly lessen the battery life.
IEEE Standards for Stationary Battery Maintenance and Monitoring (1491-2012, 1187-2013, 1188-2005, 446-1995, 1561-2019, 1657-2018, 450-2010)	IEEE	These standards will be helpful in designing and building the circuit design and appropriate electrical components for the design. It will also be helpful in finding the appropriate battery for this project.
NFPA 70 Ch 1 General, Ch 2 Wiring and Production, Ch 3 Wiring Methods and Materials, Ch 4 Equipment for General Use, & Ch 7 Special Conditions	NFPA	The benchmark for safe electrical design, installation, and inspection to protect people and property from electrical hazards.
Customer Standards	Chuck Grimm	Our battery is to be a 12V, output of inverter is to be 60Hz as per customer requirements
PIC16(L)F15313/23 Datasheet	Microchip	Shows the specifications for the PIC Microcontroller
EPPTECH FS-IR1901D optical liquid level sensor Datasheet	Amazon	Shows the specifications for the optical liquid level sensor along with setup instructions.
POTEK 500W Inverter Datasheet	Amazon	Shows the specifications for the Inverter along with setup instructions.
TMP36 Datasheet	Robotshop	Shows the specifications for the temperature sensor along with setup instructions.

Appendices:

Part Name	Datasheet
PIC16(L)F15313/23	http://ww1.microchip.com/downloads/en/DeviceDoc/PIC16_L_F15313_23_Data_Sheet_40001897C.pdf
Type B US Plug	n/a
TO-220 Aluminum Heatsink & Insulator/Mounting Kits	n/a
HiLetgo 2pcs DC 12V 2 Channel Relay Module	http://www.hiletgo.com/ProductDetail/1958433.html
IC 7805 Voltage Regulator	https://www.mouser.com/datasheet/2/149/LM7805-1010961.pdf
16 MHZ crystal	https://www.nxp.com/docs/en/application-note/AN2500.pdf
Resistors	n/a
Ceramic Capacitor	n/a
Diode	n/a
8 mm LED Indicator 5V6V Green	n/a
Plugin Receptacle	https://www.amazon.com/gp/product/B07MSGGNM8/ref=ppx_yo_dt_b_asin_title_o08_s00?ie=UTF8&psc=1
EPTTECH FS-IR1901D Optical Infrared Water Oil Liquid Tank Agriculture Irrigation Level Sensor"	https://www.eptsensor.com/uploads/201921312/liquid-level-probe-sensor.pdf
TMP36	https://www.analog.com/media/en/technical-documentation/data-sheets/TMP35_36_37.pdf
POTEK 500W Inverter	https://www.potekelec.com/product/302/500w-power-inverter-black
12V Marine Lead Acid Battery	n/a

Battery Charger	https://www.amazon.com/Adakiit-Maintainer-Automatic-Automotive-Motorcycle/dp/B07ZCXDQSP
24-31 Snap-Top Battery Box	https://no.co/media/nocodownloads/format/h/m/hm318bks-snap-top_product_sell_sheet.pdf
Battery Terminal 5/16"	n/a
Wires	https://images.homedepot-static.com/catalog/pdfImages/6e/6e774b04-b0e1-41c6-8eb4-3f36d06ac3e6.pdf
100uf, 6.3V Capacitor	n/a
2.54mm Male Pin Header Connector Strip 3 Position	https://www.mouser.com/catalog/additional/Amphenol_bwb_bergstik.pdf
8mm LED Indicator 5V6V Yellow	n/a
8mm LED Indicator 5V6V Red	n/a

Project Timeline

	Task Mode	Task Name	Duration	Start	Finish	% Work Complete	Owner	Predecessors
1		**Bullet Proof Battery Project: Haiti**	**232 days?**	**Fri 1/24/20**	**Sat 12/12/20**	**100%**		
2		**Documentation Design Phase 1**	**72 days**	**Fri 1/24/20**	**Mon 5/4/20**	**100%**		
3		**Project Charter**	**3 days**	**Fri 1/24/20**	**Tue 1/28/20**	**100%**		
10		**VOC, Scope**	**4 days**	**Tue 2/11/20**	**Fri 2/14/20**	**100%**		
15		**Signed Functional Specifications**	**11 days**	**Fri 2/14/20**	**Fri 2/28/20**	**100%**		
26		**Block Diagram**	**10 days**	**Sat 2/22/20**	**Fri 3/6/20**	**100%**		
32		**High Level Design/Design Trade-Off Analysis**	**11 days**	**Fri 2/28/20**	**Fri 3/13/20**	**100%**		
37		**Draft Test Plan**	**4 days**	**Tue 3/10/20**	**Sun 3/15/20**	**100%**		
41		**Subsystems Document**	**14 days**	**Tue 3/17/20**	**Fri 4/3/20**	**100%**		
48		**Low Level Design**	**17 days**	**Sat 4/4/20**	**Tue 4/28/20**	**100%**		
55		Project Timeline	7 days	Sat 4/18/20	Sun 4/26/20	100%		
56		Capstone Project Presentation (Design Phase)	1 day	Tue 4/28/20	Tue 4/28/20	100%		
57		Oral Presentation	7 days	Mon 4/20/20	Tue 4/28/20	100%		
58		PEER assessment on Group Project	1 day	Mon 5/4/20	Mon 5/4/20	100%		
59		**Design Phase**	**89 days?**	**Wed 4/29/20**	**Sun 8/30/20**	**100%**		
60		Research parts and make decision matricies	13 days	Wed 4/29/20	Fri 5/15/20	100%		
61		Bill of Materials	1 day	Fri 5/15/20	Fri 5/15/20	100%		
62		Final Requirement Specification(signed)	5 days	Mon 8/24/20	Fri 8/28/20	100%		
63		Testing Specifications(signed)	5 days	Mon 8/24/20	Fri 8/28/20	100%		
64		Revised LLD	2 days	Fri 8/28/20	Sun 8/30/20	100%		
65		Weekly Progress Report 1	6 days	Mon 8/24/20	Sun 8/30/20	100%		
66		**Build Phase**	**15 days**	**Mon 8/31/20**	**Sun 9/20/20**	**100%**		
67		Test Battery	5 days	Mon 8/31/20	Fri 9/4/20	100%	Vincent and Tiffany	
68		Build Battery Subsystem	6 days	Mon 8/31/20	Sun 9/6/20	100%	Vincent and Tiffany	67
69		Weekly Progress Report 2	5 days	Mon 8/31/20	Fri 9/4/20	100%		
70		Build Inverter Subsystem	6 days	Mon 9/7/20	Sun 9/13/20	100%	Vincent	
71		Schedule Mid-Semester Design Review	6 days	Sat 9/5/20	Fri 9/11/20	100%		
72		Test LEDS	6 days	Mon 9/7/20	Sun 9/13/20	100%	Tiffany	
73		Programming Crystal	6 days	Mon 9/7/20	Sun 9/13/20	100%	Walla	
74		Weekly Progress Report 3	5 days	Mon 9/7/20	Fri 9/11/20	100%		
75		Test Water Level Sensor	5 days	Mon 9/14/20	Fri 9/18/20	100%	Tiffany	
76		Build Sensor Subsystem	6 days	Fri 9/11/20	Fri 9/18/20	100%	Tiffany	72
77		Programming LEDS	6 days	Mon 9/14/20	Sun 9/20/20	100%	Walla	72
78		Build Load and Battery Protection	5 days	Mon 9/14/20	Fri 9/18/20	100%	Tiffany	
79		Build Microcontroller Subsystem	6 days	Fri 9/11/20	Fri 9/18/20	100%	Walla	
80		Build Relay and Mosfet Subsystem	6 days	Fri 9/11/20	Fri 9/18/20	100%	Vincent	
81		Weekly Progress Report 4	5 days	Mon 9/14/20	Fri 9/18/20	100%		
82		Demonstrate Subsystems to Advisor	1 day	Wed 9/23/20	Wed 9/23/20	100%		
83		Integrate Subsystems	5 days	Mon 9/21/20	Fri 9/25/20	100%		66
84		Programming Water Level	9 days	Fri 9/25/20	Wed 10/7/20	100%	Walla	75

	Task Mode	Task Name	Duration	Start	Finish	% Work Complete	Owner	Predecessors
85		Weekly Progress Report 5	5 days	Mon 9/21/20	Fri 9/25/20	100%		
86		Integrate Subsystems	5 days	Mon 9/28/20	Fri 10/2/20	100%		66
87		Weekly Progress Report 6	5 days	Mon 9/28/20	Fri 10/2/20	100%		
88		Integrate Subsystems	5 days	Mon 10/5/20	Fri 10/9/20	100%		66
89		Finish and Print PCB layout	11 days	Wed 9/30/20	Wed 10/14/20	100%		83FF+13 days
90		Programming Voltage Sensor	8 days	Thu 10/8/20	Sun 10/18/20	100%		
91		Weekly Progress Report 7	5 days	Mon 10/5/20	Fri 10/9/20	100%		
92		Mid Semester Gantt Chart	4 days	Wed 10/7/20	Mon 10/12/20	100%		
93		Mid Semester Presentation	24 days	Mon 9/14/20	Thu 10/15/20	100%		71
94		Weekly Progress Report 8	5 days	Mon 10/12/20	Fri 10/16/20	100%		
95		Receive PCB Board	1 day	Wed 10/21/20	Wed 10/21/20	100%		
96		Run Tests with 5v voltage regulator circuit on PCB Board/Battery Setup	12 days	Wed 10/21/20	Thu 11/5/20	100%	Vincent and Tiffany	95
97		Build Battery System	32 days	Fri 10/16/20	Mon 11/30/20	100%	All	
98		**Test Phase**	**40 days**	**Mon 10/19/20**	**Fri 12/11/20**	**100%**		
99		Weekly Progress Report 9	5 days	Mon 10/19/20	Fri 10/23/20	100%		
100		Run Tests with Water Level Sensor on PCB Board/Battery Setup	28 days	Mon 10/26/20	Wed 12/2/20	100%	Walla and Tiffany	95
101		Run Tests with Temp Sensor on PCB Board/Battery Setup	24 days	Fri 10/30/20	Wed 12/2/20	100%	Walla and Tiffany	95
102		Test Battery system	35 days	Mon 10/26/20	Fri 12/11/20	100%	All	97
103		Weekly Progress Report 10	5 days	Mon 10/26/20	Fri 10/30/20	100%		
104		Teaming Assessment on	1 day	Mon 11/2/20	Mon 11/2/20	100%		

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	Task Mode	Task Name	Duration	Start	Finish	% Work Complete	Owner	Predecessors
102		Test Battery system	35 days	Mon 10/26/20	Fri 12/11/20	100%	All	97
103		Weekly Progress Report 10	5 days	Mon 10/26/20	Fri 10/30/20	100%		
104		Teaming Assessment on Group Project	1 day	Mon 11/2/20	Mon 11/2/20	100%		
105		Test Battery System with Laptop and Projector	10 days	Mon 11/30/20	Fri 12/11/20	100%	All	97
106		Weekly Progress Report 11	5 days	Mon 11/2/20	Fri 11/6/20	100%		
107		Weekly Progress Report 12	5 days	Mon 11/9/20	Fri 11/13/20	100%		
108		Report Draft	5 days	Mon 11/16/20	Fri 11/20/20	100%		
109		Make Technical Manual for Battery System	14 days	Wed 10/28/20	Sat 11/14/20	100%		
110		Make General User's Guide for Battery System	18 days	Wed 10/28/20	Fri 11/20/20	100%		
111		Translate General User's Guide to French Creole	10 days	Fri 11/20/20	Thu 12/3/20	100%		110
112		Project Poster Final Version	3 days	Thu 11/19/20	Mon 11/23/20	100%		
113		Final Technical Presentation to Faculty	1 day	Thu 12/3/20	Thu 12/3/20	100%		
114		Final Presentation to IAB/Students/Faculty	1 day	Fri 12/4/20	Fri 12/4/20	100%		
115		Peer Assessment on Group Project	1 day	Sun 12/6/20	Sun 12/6/20	100%		
116		Project Function	6 days	Fri 12/4/20	Fri 12/11/20	100%		
117		Fall 2020 Capstone Zoom Event	1 day	Fri 12/11/20	Fri 12/11/20	100%		
118		Final Report	4 days	Wed 12/9/20	Sat 12/12/20	100%		

Notes

Calculations:

PIC16: 800mW or 0.8Watts

TMP36: P=IV V=2.7V-5.5V I=0.05mA P=(2.7)(0.00005)= 0.135 mW

P=(5.5)(0.00005) = 0.275mW

P = 0.135mW-0.275mW

EPPTECH-WLS: (in air) P= 75mW-125mW (in water)= 50mW-100mW

Voltage Regulator(L7805CV): 5.6W Current –800mA Voltage –5V

P= V*I=(Vin-Vout)*I=(12-5)*0.8= 5.60W

Green LED: 0.2Watts(rated on ebay)Current-20mA Voltage –5V/6V

Diode:P= Vf*If= 0.7*0.1= 70mW (from Data Sheet)

Red LED: 0.2Watts(rated on ebay)Current-20mA Voltage –5V/6V

Yellow LED: 0.2Watts(rated on ebay)Current-20mA Voltage –5V/6V

Relay: P=IV V=5V I=2.48mA

P = (5)(0.00248) = 12.4mW

PIC16: 800mW or 0.8Watts **TMP36**: 0.135mW – 0.275mW Voltage=2.7V-5.5V Current =0.05mA **EPPTECH-WLS**: (in air) P= 75mW-125mW (in water)= 50mW-100mW **Voltage Regulator:** 5.6Watts Current – 800mA Voltage – 5V **Relay:** 12.4mW Current- 2.48mA Voltage – 5V	**Green LED:** 0.2Watts(rated on ebay) Current- 20mA Voltage – 5V/6V **Red LED:** 0.2Watts(rated on ebay) Current- 20mA Voltage – 5V/6V **Yellow LED:** 0.2Watts(rated on ebay) Current- 20mA Voltage – 5V/6V **Diode:** P= V_f*I_f= 0.7*0.1= 70mW (from Data Sheet)
Total Power Consumption of BPB System = 7.21Watts(max)	